



# Central Nervous System

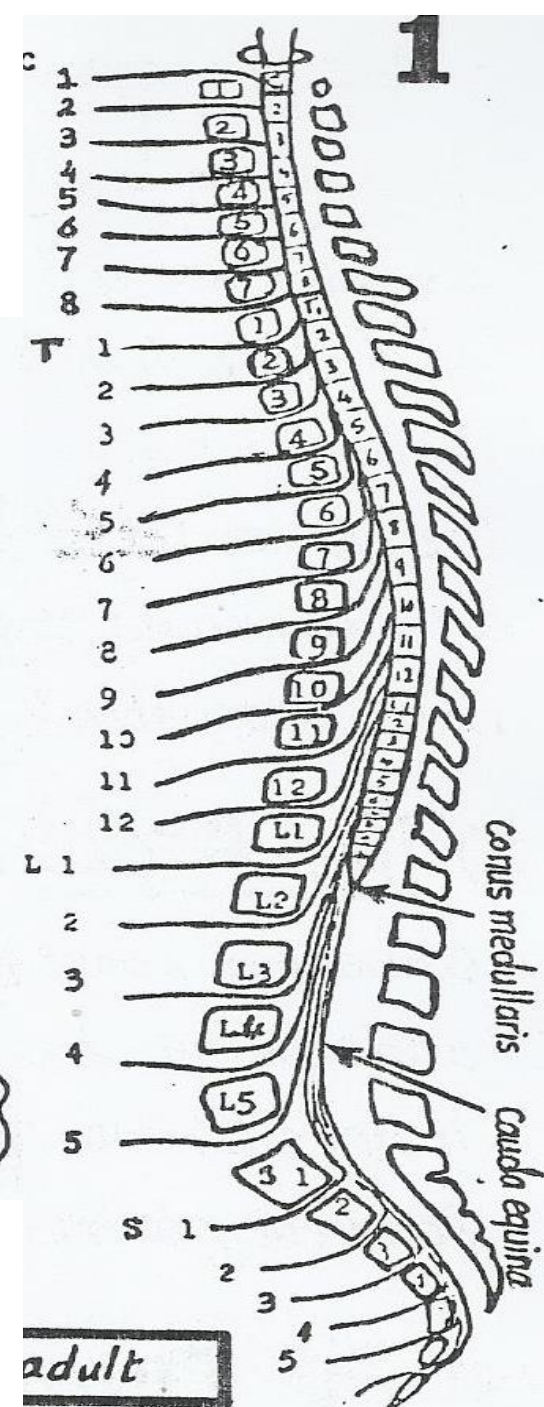
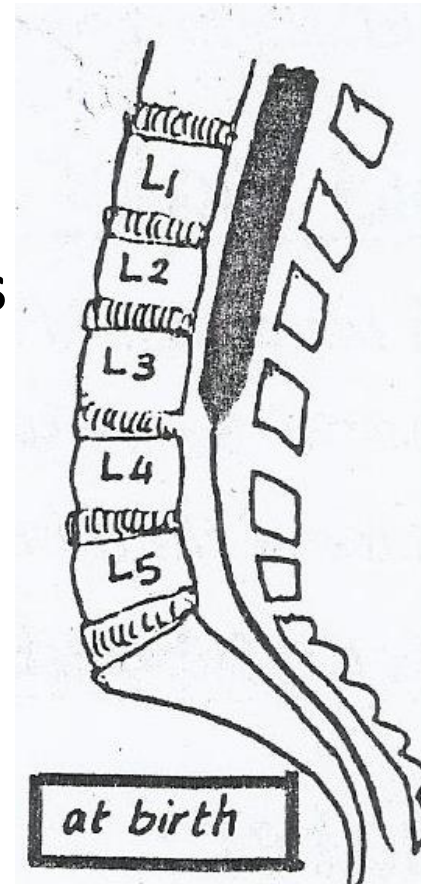
## Lecture 2: Spinal Cord

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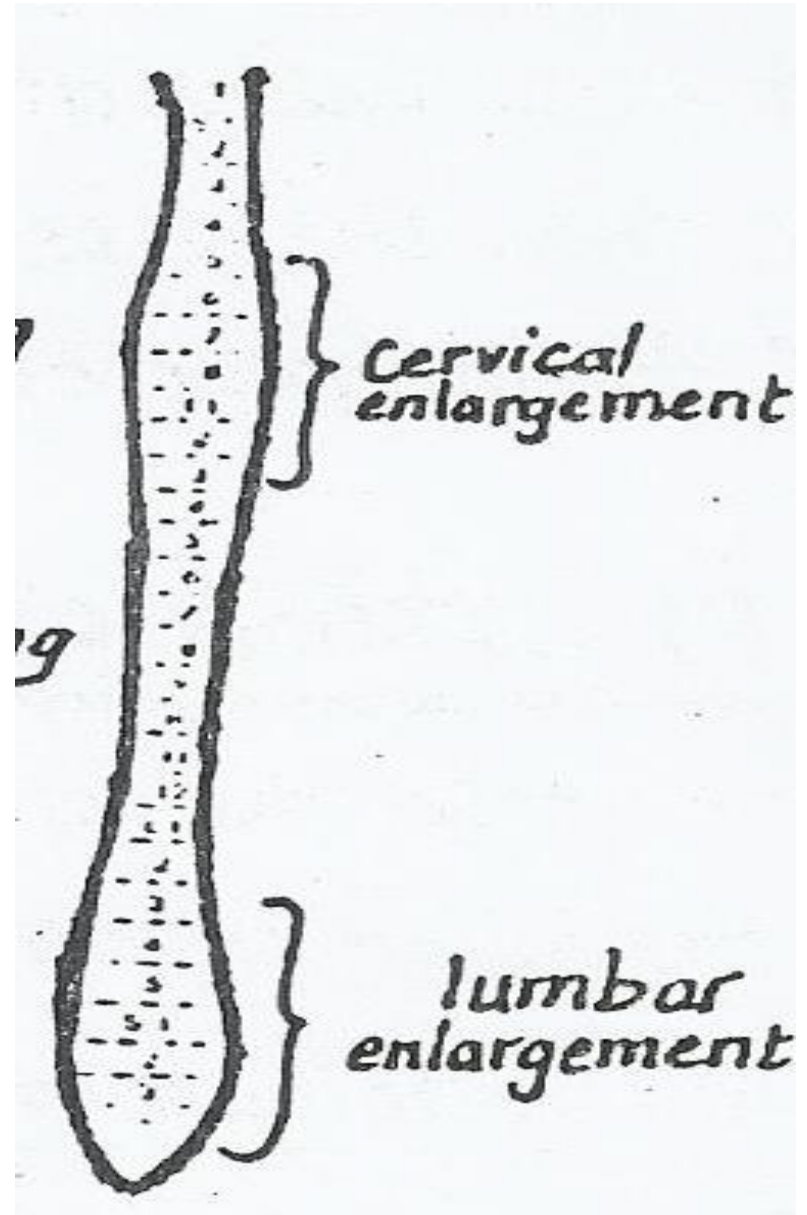
# Spinal Cord

## \*\* Site:

- \* Occupies the upper 2/3 of the vertebral canal.
- \* Begins opposite the upper border of Atlas vertebra, as a continuation of the medulla oblongata.
- \* Ends opposite the disc between L1 & 2 in adults. At birth, it ends opposite L3. Later, the vertebral column grows faster than the spinal cord.



- \*\* Length: 45 cm.
- \*\* Shape: cylindrical but shows:
- \* 2 enlargements:
  1. **Cervical enlargement**: gives origin to brachial plexus (C4-T1).
  2. **Lumbar enlargement**: gives origin to lumbar & sacral plexuses (L1-S4).
- \* A tapering lower end called **conus medullaris**. From its apex, a thin filament of pia mater called filum terminale extends down to be attached to the back of coccyx.

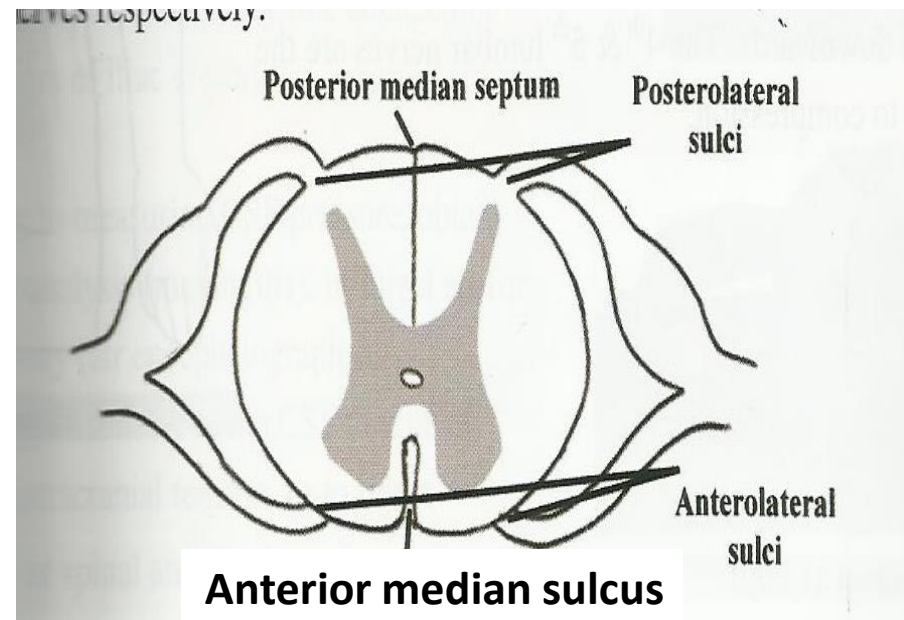


**\*\* 31 segments → 8 cervical, 12 thoracic, 5 lumbar, 5 sacral & 1 coccygeal.**

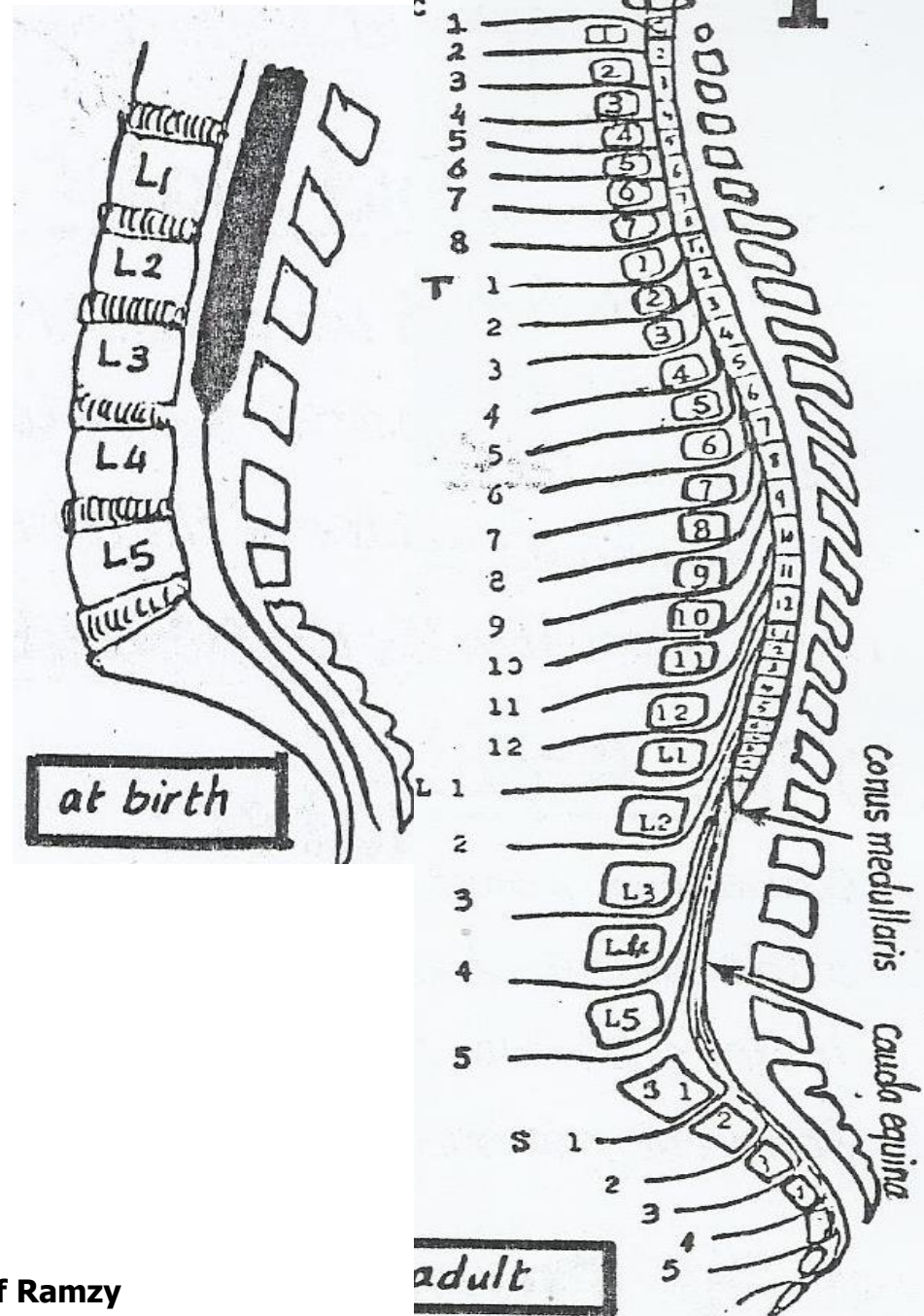
**\*\* Segments** are not demarcated externally but each segment gives origin to a pair of spinal nerves.

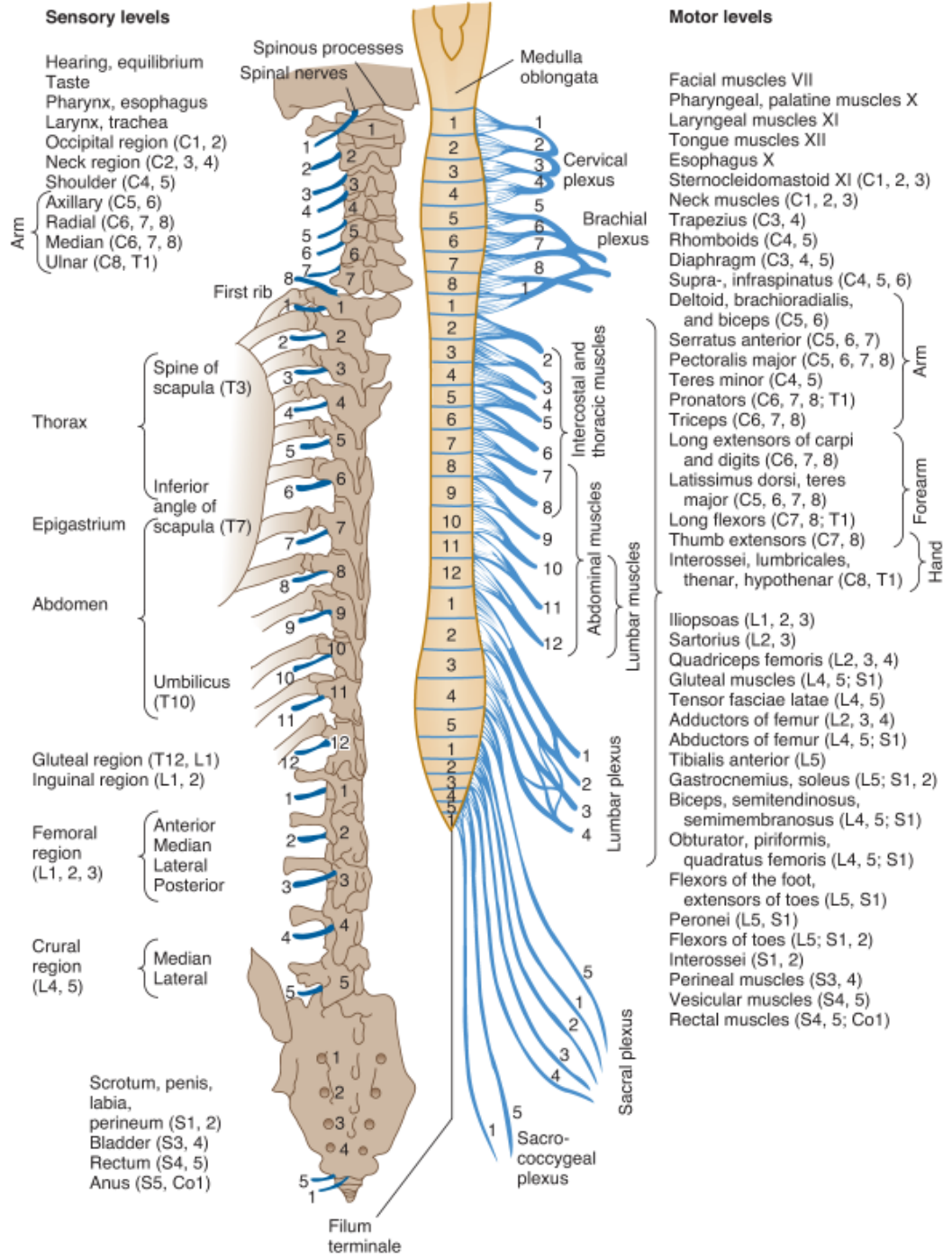
**\*\* Longitudinal grooves:**

- 1. an anterior median fissure & a posterior median septum** divide the cord almost completely into right and left halves.
- 2. 2 posterolateral & 2 anterolateral sulci** give attachment to posterior & anterior roots of spinal nerves respectively.



- \*\* **Levels:** spinal cord segments do not lie opposite the corresponding vertebrae
- \* **In the cervical region** → -1 (e.g., C6 segment is opposite C5 vertebra).
- \* **In the upper 6 thoracic segments** → - 2 (e.g., T6 segment is opposite T4 vertebra).
- \* **In the lower 6 thoracic segments** → - 3 (e.g., T12 segment is opposite T9 vertebra).
- \* **In the lumbar segments** → - 4 (e.g., L5 is opposite L1 vertebra).
- \* **All sacral & coccygeal segments** → opposite L1-L2 vertebrae.



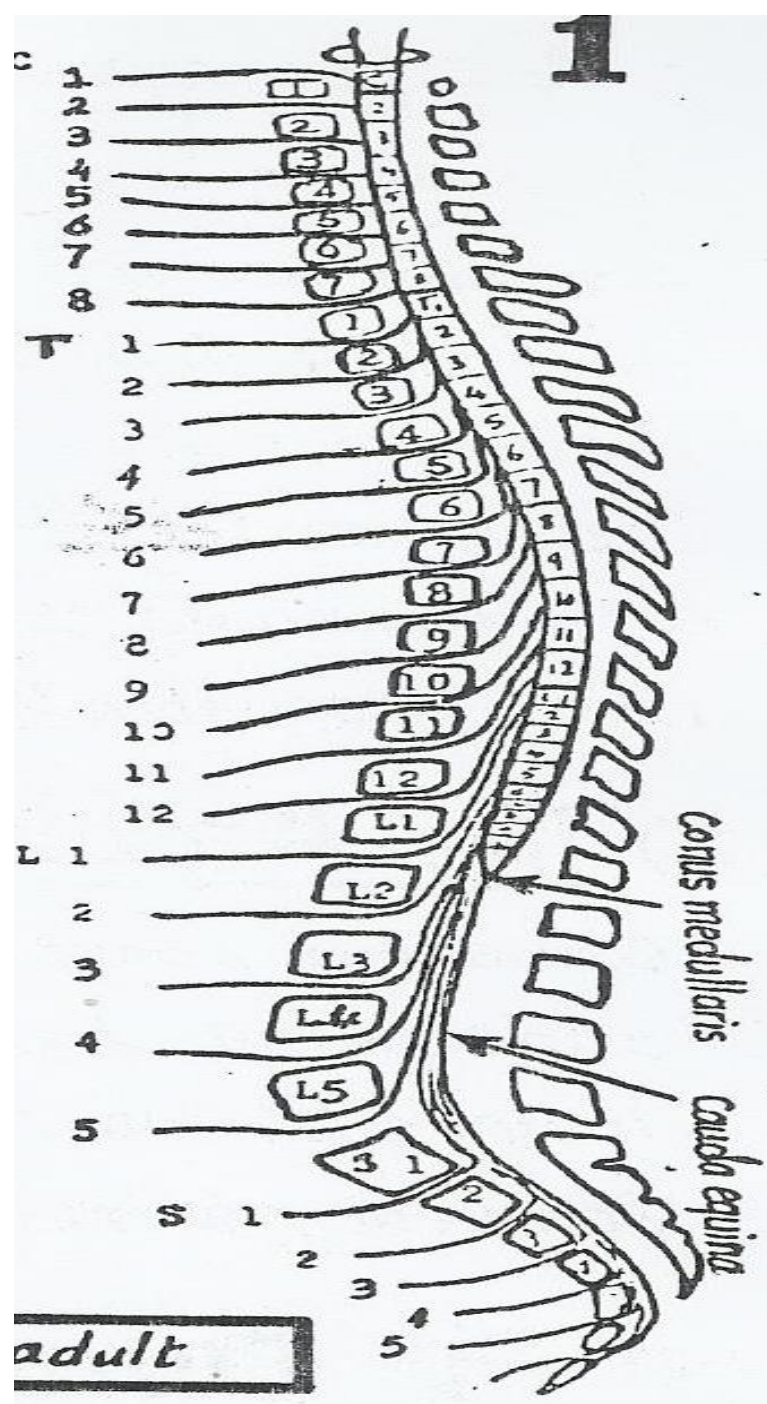


**\*\* Direction of roots:**

- C1&2 are horizontal.
- C3-T12 are oblique.
- L1-Co are vertical.

**\*\* Exit of spinal nerves from the vertebral canal:**

- \* C1-7 pass above corresponding vertebrae.
  - \* C8 passes below C7 vertebra.
  - \* T1-L5 pass below corresponding vertebra. (C2-L5 exit via intervertebral foramina)
  - \* S1-4 pass via the ant. & post. sacral foramina.
  - \* S5 & Co pass via the sacral hiatus.
- \*\* The collection of spinal nerves that surround the film terminale below the termination of the spinal cord (i.e., below L2) is called **cauda equina** because it resembles a horse tail. They occupy the lower 1/3 of the vertebral canal & the sacral canal.**



## NUMBERING OF CERVICAL SPINAL NERVES

### LEVELS OF SPINAL NERVES

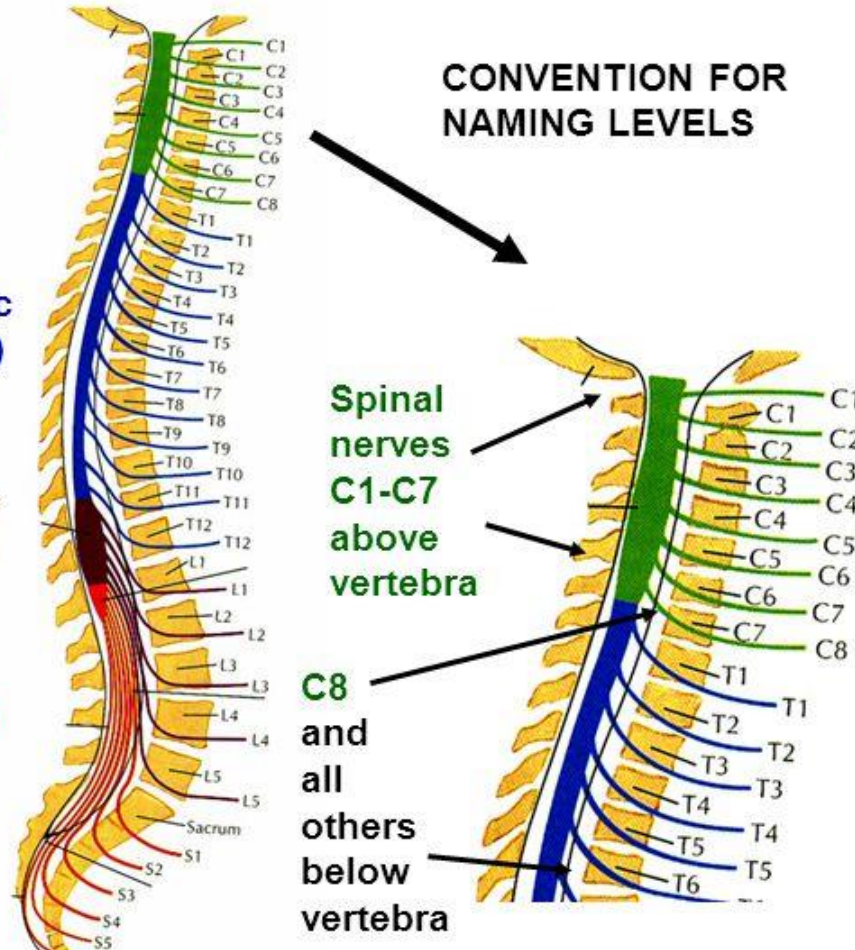
Cervical (C1-C8)

Thoracic (T1-T12)

Lumbar (L1-L5)

Sacral (S1-S5)

Coccygeal (Co1)

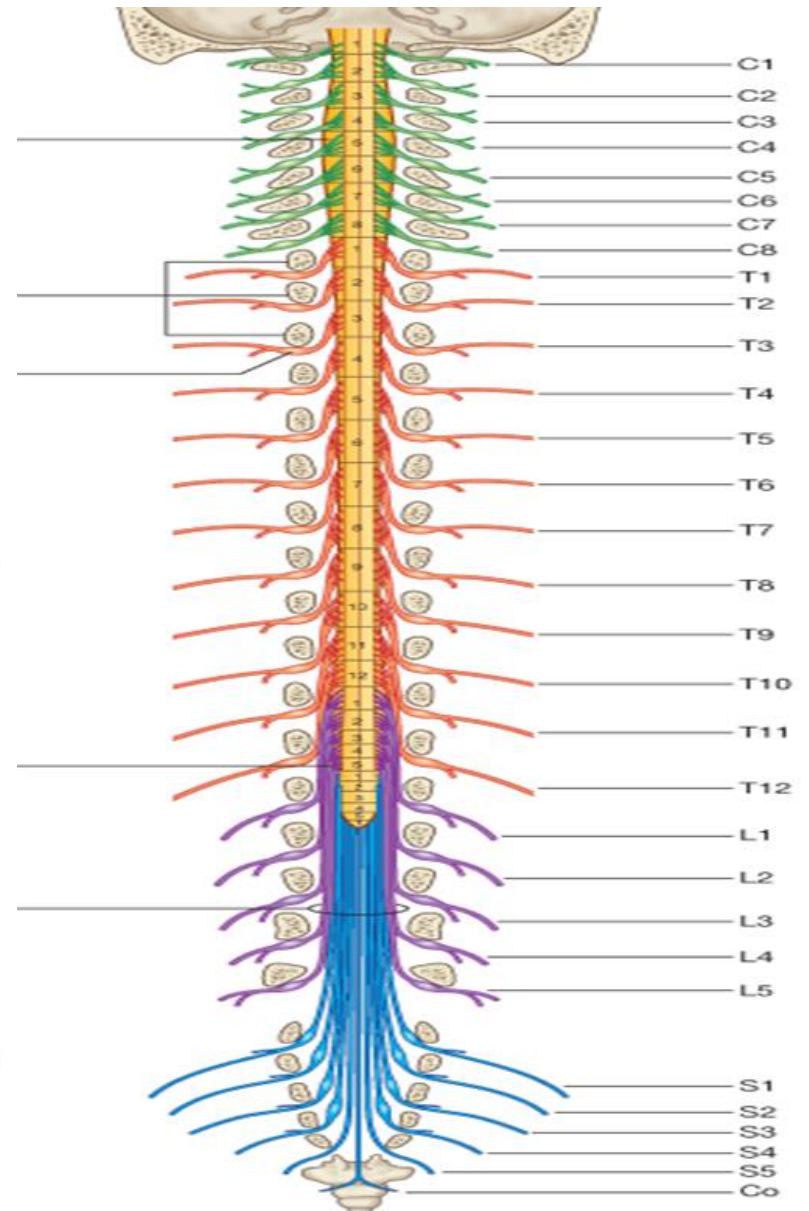
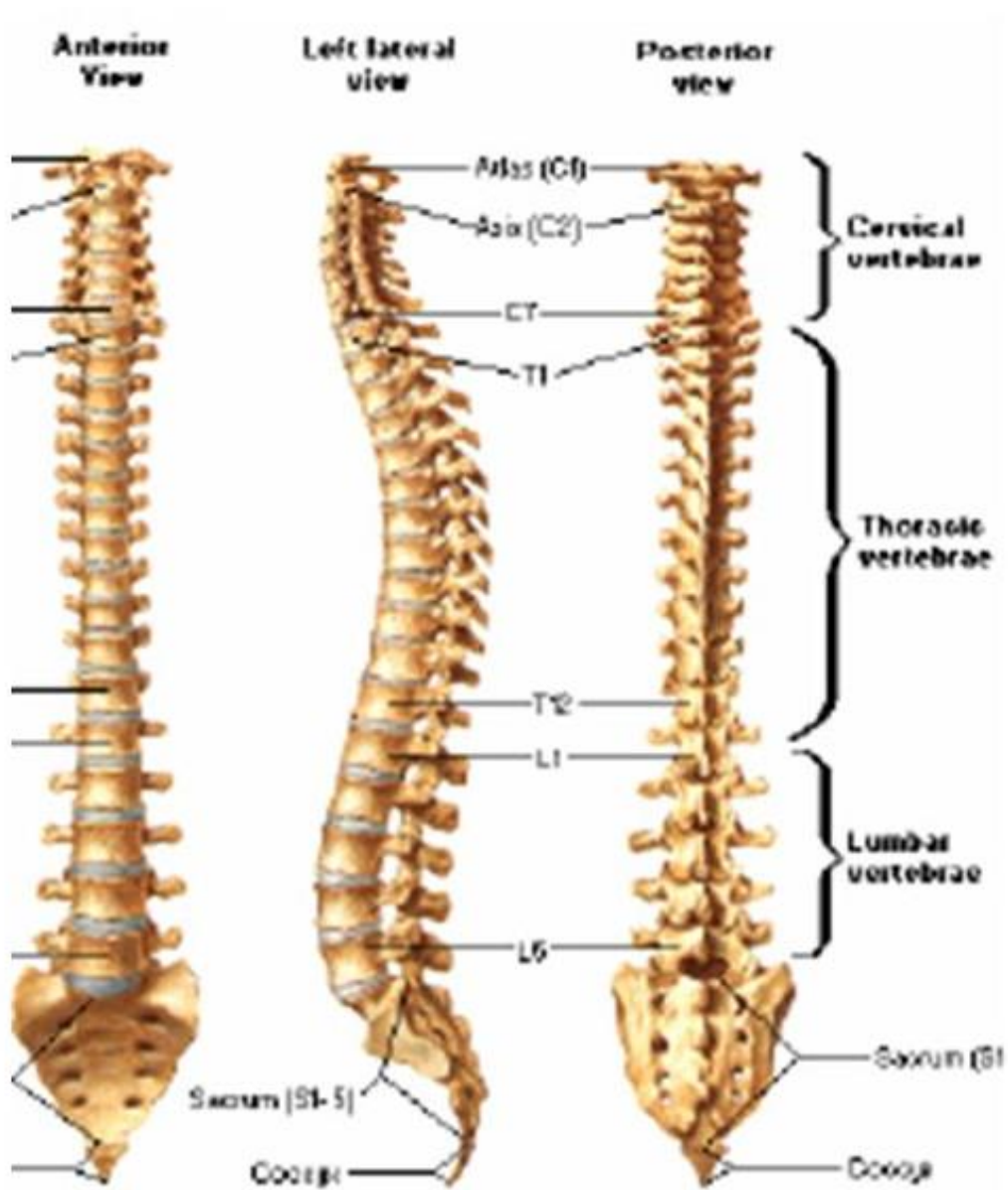


**Spinal nerves** - arise from/project to spinal cord; there are 31 spinal nerves (8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal).

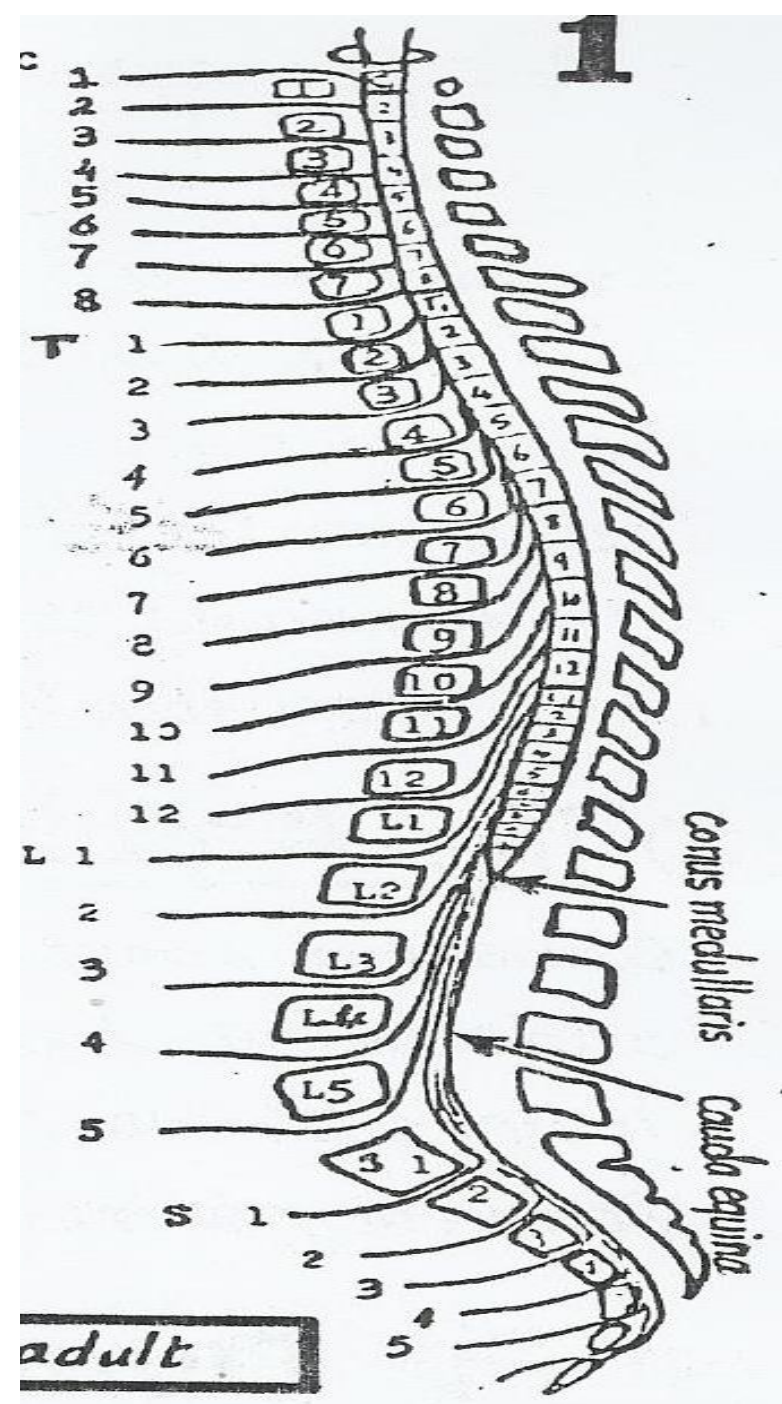
**Note: Cervical spinal nerves 1-7 (C1-C7) exit above corresponding vertebrae; Spinal nerve C8 exits below vertebra C7; All other spinal nerves exit below corresponding vertebrae.**

**SPINAL NERVE C6 ARISES ABOVE VERTEBRA C6**



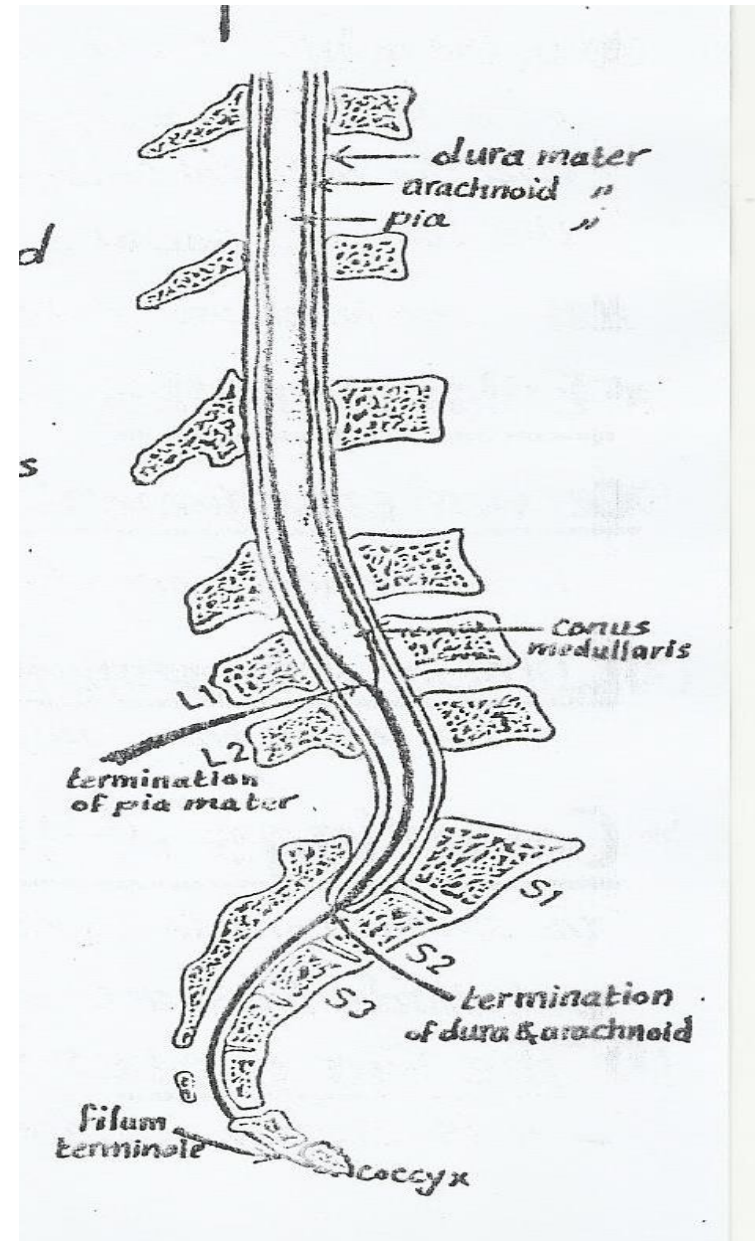


**\*\* Applied anatomy: Nerve compression: The size of the spinal nerves increases gradually from above downwards. The largest spinal nerve is the 1st sacral. Meanwhile, the size of the intervertebral foramina decreases from above downwards. The 4th & 5th lumbar nerves are the most liable to compression.**



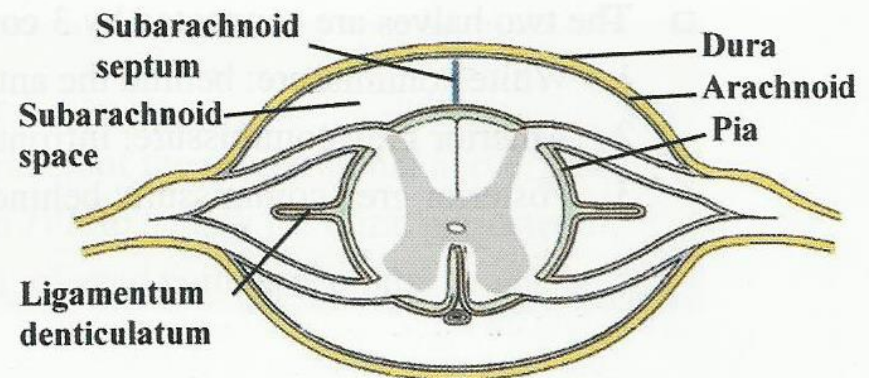
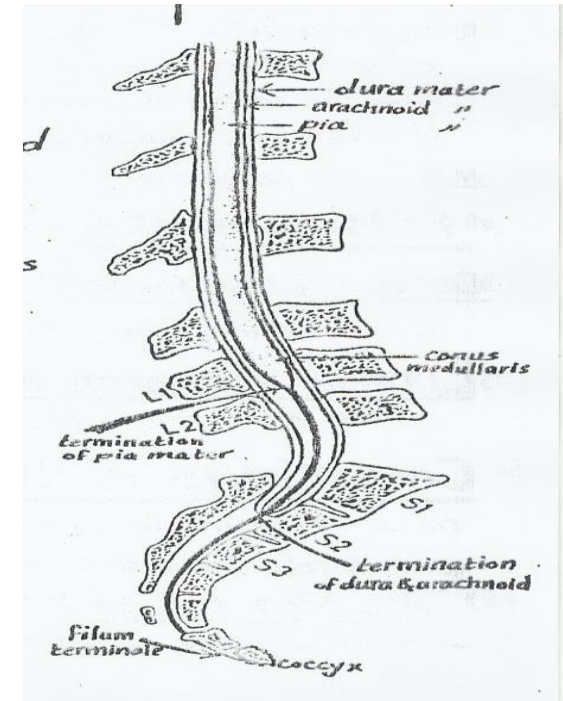
# The 3 meningeal coverings of spinal cord

1. The dura mater (outer layer) & arachnoid mater (middle layer): form one tube together. Above, it is continuous with the cerebral meninges at the foramen magnum. Below, it ends opposite S2.
2. Pia mater (inner layer): is adherent to the cord & continuous below as the filum terminale which pierces the tube of dura & arachnoid to be attached to the back of coccyx.



# Spaces between meninges

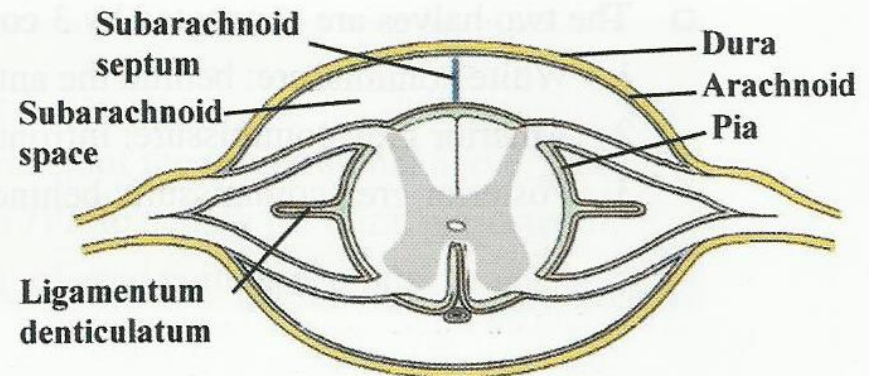
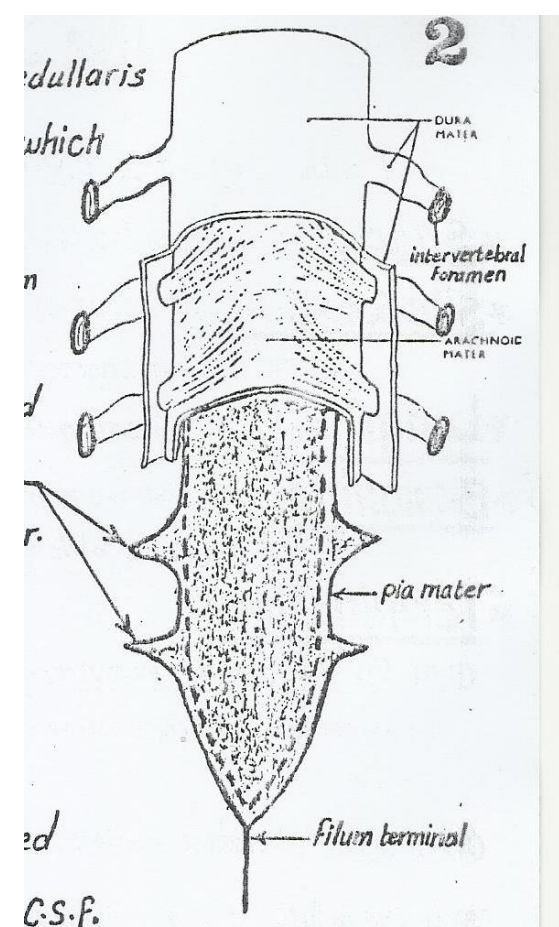
1. **Extradural (epidural) space**: between the dura and walls of vertebral canal. Contains fat, small arteries, venous plexus & lymphatics.
2. **Subdural space**: between the dura & arachnoid. Contains a thin film of fluid
3. **Subarachnoid space**: between the arachnoid & pia → contains CSF + 3 ligaments supporting the spinal cord:



a. **Filum terminale.**

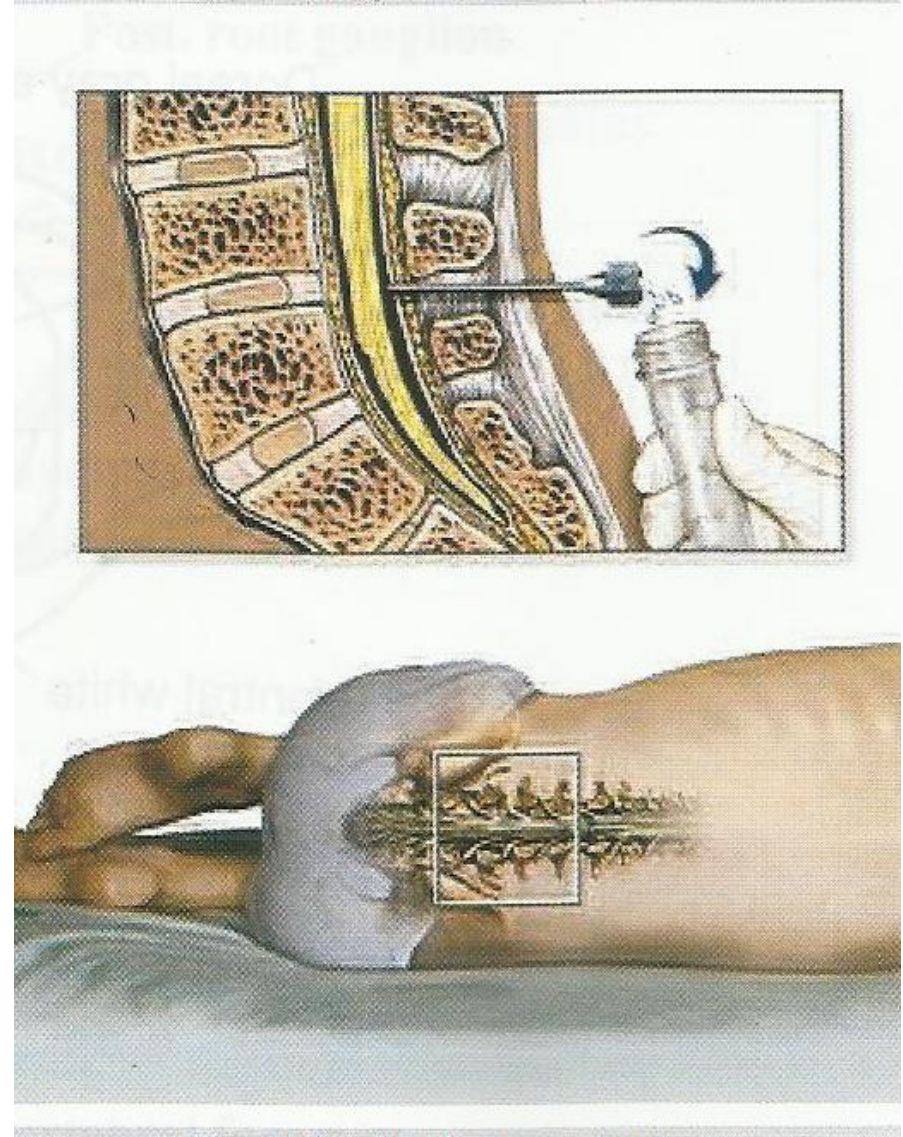
b. **Ligamentum denticulatum:**  
one on each side of the cord, extending laterally between the anterior and posterior roots of spinal nerves. Laterally, it has 21 teeth connecting the pia (on one side) to the arachnoid and dura (on the other side).

c. **Subarachnoid septum:**  
extends from the posterior median septum to the arachnoid mater.



# Applied: Lumbar Puncture

- \*\* **A needle** is introduced to the spinal subarachnoid space below the end of the spinal cord
- \*\* **Site:** Just above or just below the tip of 4th lumbar spine (which lies opposite an imaginary line connecting the highest points of iliac crests).
- \*\* **Uses:**
  1. **Diagnostic:** to measure CSF pressure, obtain sample for analysis (meningitis), or inject air for contrast X-ray (air encephalography).
  2. **Therapeutic:** to remove some CSF to relieve increased intracranial tension, or to inject antibiotics or spinal anesthesia.



# INTERNAL STRUCTURE

**\*\* The spinal cord is formed of a central H-shaped grey matter surrounded by white matter.**

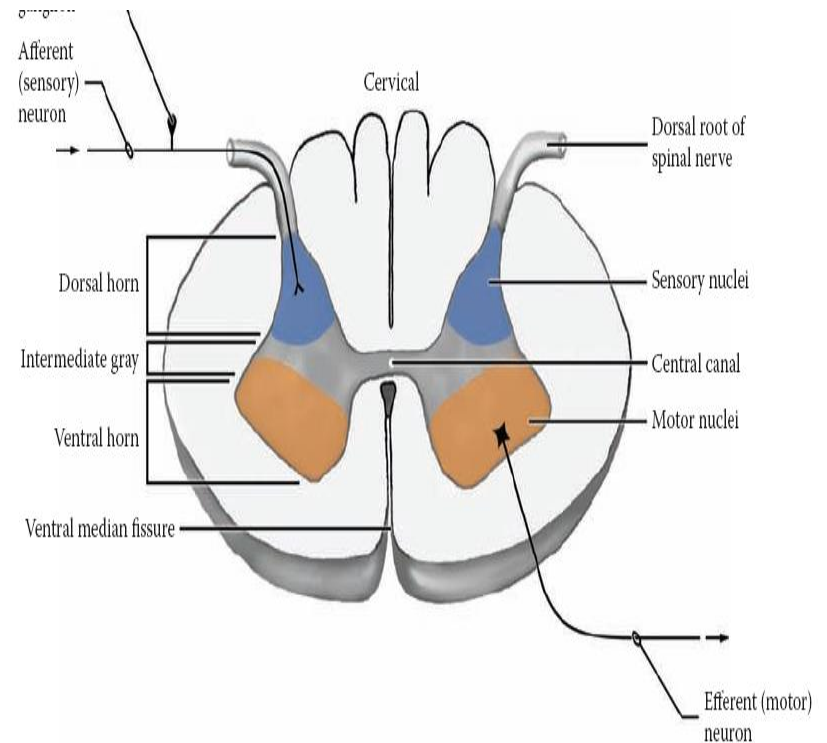
**\*\* Grey matter:**

**\* Parts:**

- 1. Anterior horn [motor]**
- 2. Posterior horn [sensory]**
- 3. ± Lateral horn [autonomic]**

**\* Structure:**

- 1. Nerve cells (nuclei).**
- 2. Unmyelinated nerve fibers.**
- 3. Neuroglia.**
- 4. Capillaries.**



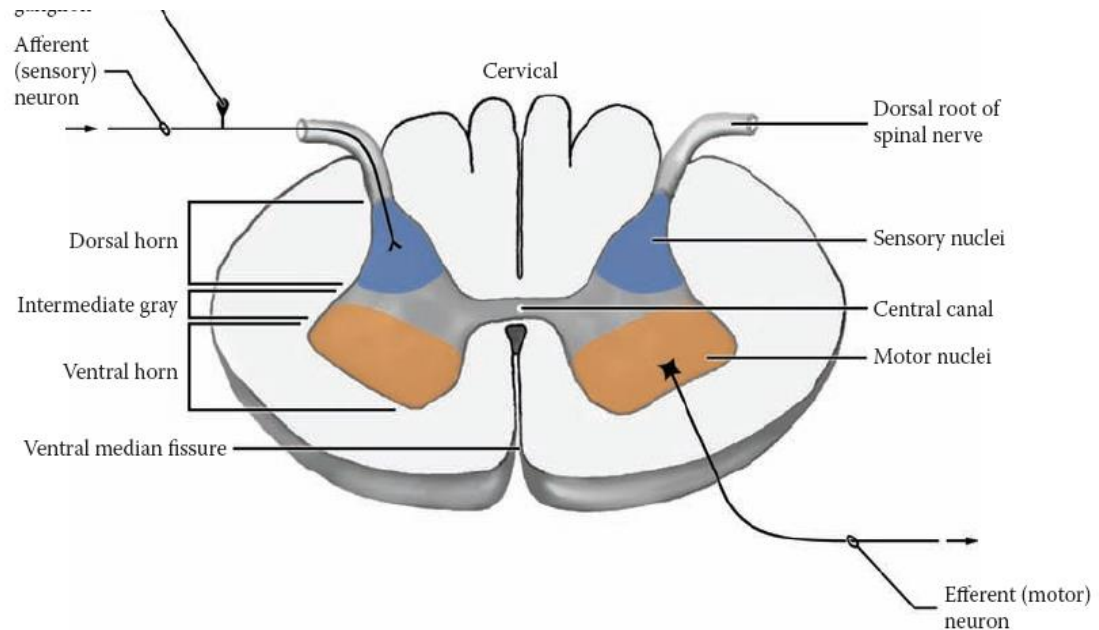
## **\*\* White matter:**

### **\* Parts:**

- 1. Anterior column (funiculus).**
- 2. Lateral column (funiculus).**
- 3. Posterior column (funiculus).**

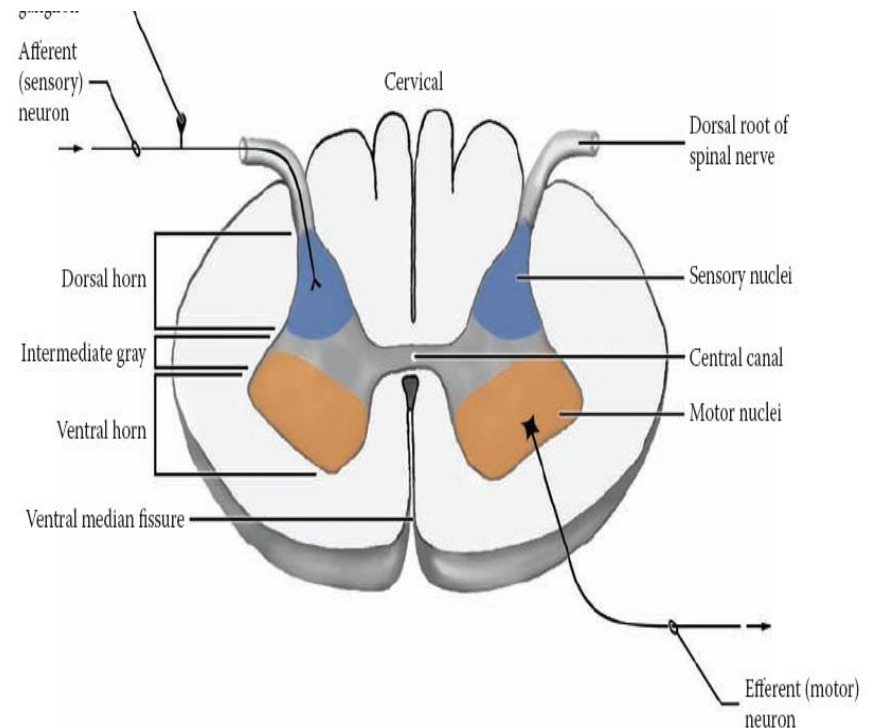
### **\* Structure:**

- 1. Myelinated nerve fibers (tracts).**
- 2. Neuroglia.**
- 3. Capillaries.**





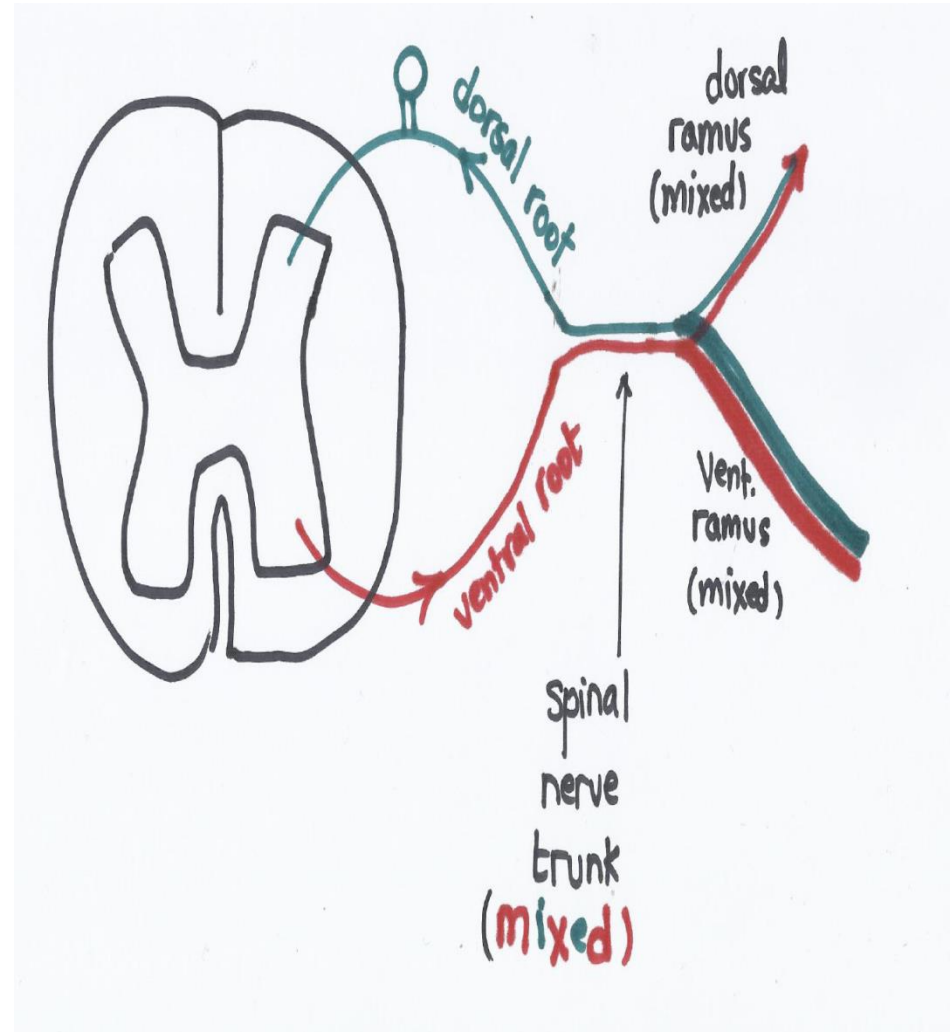
- \*\* Its center contains a narrow **central canal** extending throughout the length of spinal cord.
- \*\* The cord is divided into **right & left halves** by an anterior median sulcus & a posterior median septum.
- \*\* The two halves are connected by 3 commissures:
  1. **White commissure:** behind the anterior median sulcus.
  2. **Anterior grey commissure:** in front of the central canal.
  3. **Posterior grey commissure:** behind the central canal.



# ATTACHMENT OF SPINAL NERVES

A. Each spinal nerve arises from a spinal cord segment by 2 roots:

1. Anterior root: contains
  - Motor fibers (from the anterior horn)
  - ± Autonomic fibers (from the lateral horn).
2. Posterior root: purely sensory. It carries post. root ganglion (spinal ganglion) containing pseudounipolar neurons. Their peripheral processes (dendrites) pass peripherally, while their central processes (axons) enter the cord at the posterolateral sulcus.

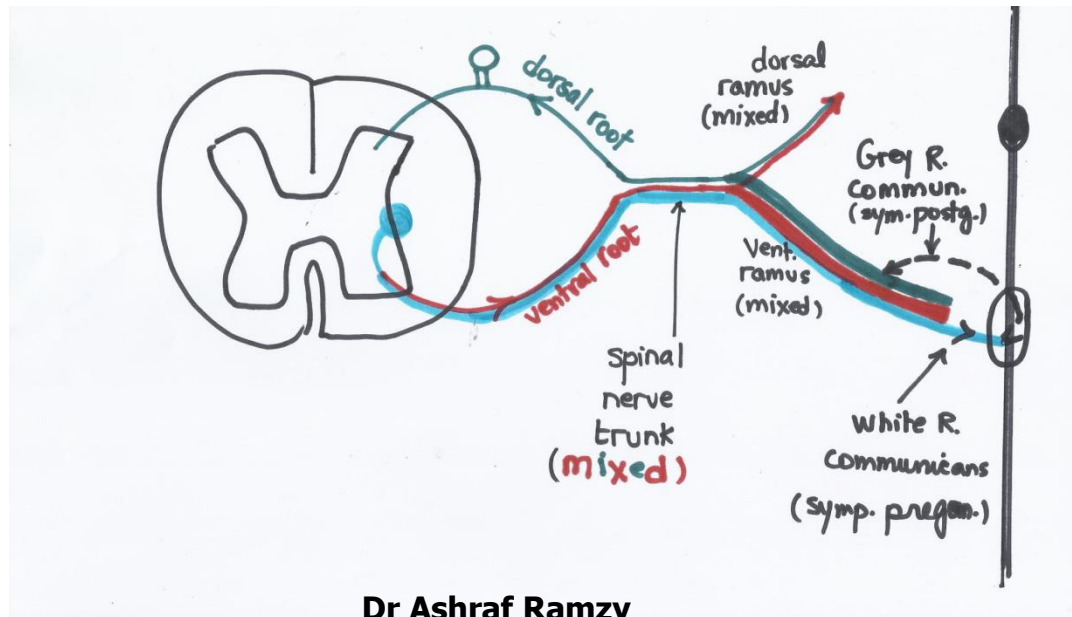


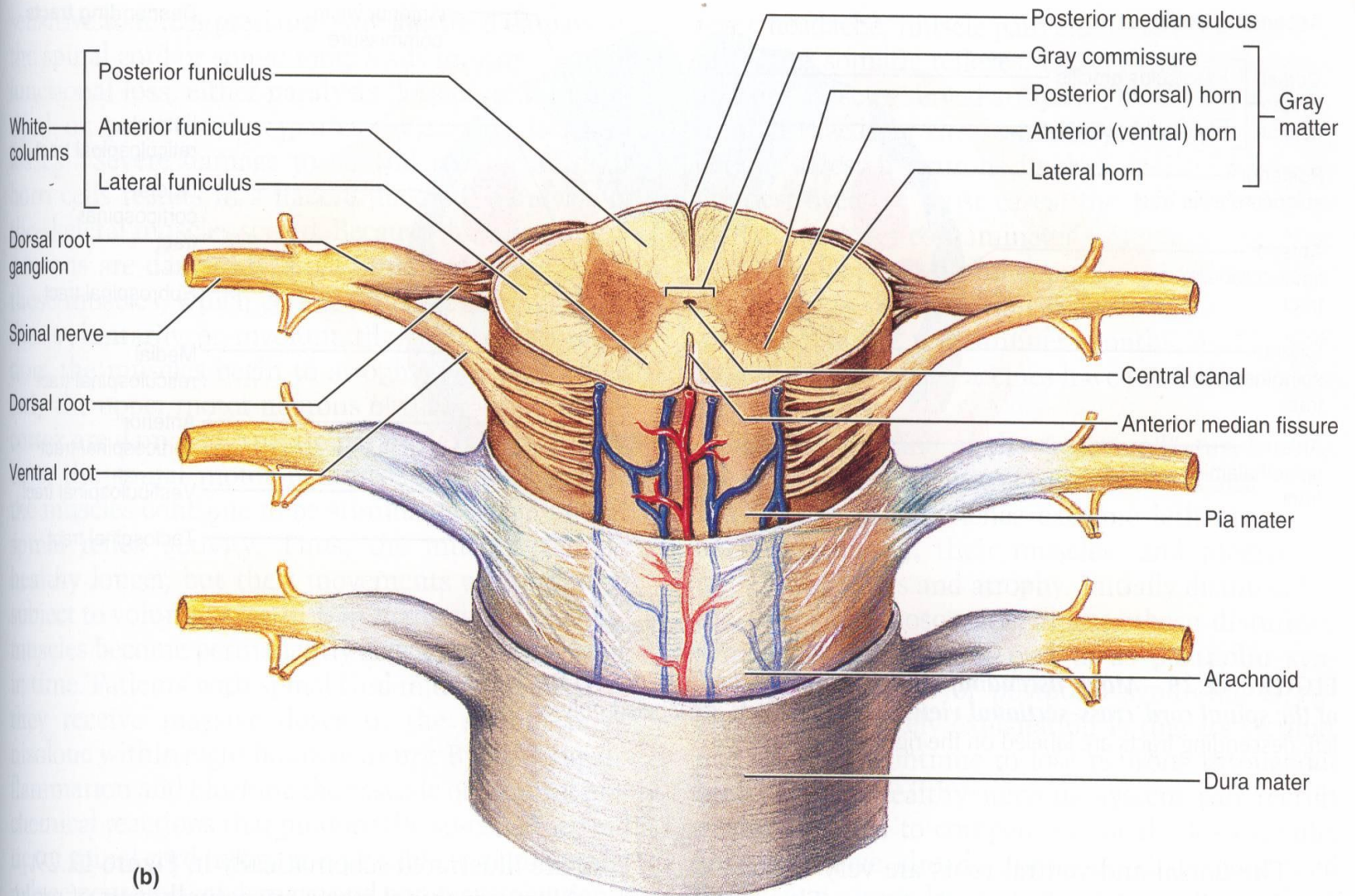
**B. Both roots unite forming a mixed nerve, which exits the vertebral canal through the intervertebral foramen (IVF) and soon divides into 2 rami (both are mixed):**

**1. Anterior ramus (large):**

- \* All anterior rami form plexuses except the 12 thoracic (intercostal nerves).
- \* Only 14 anterior rami (12 thoracic + upper 2 lumbar) send white rami communicants [preganglionic] to sympathetic ganglia.
- \* All 31 anterior rami receive grey rami communicants [postganglionic] from sympathetic ganglia.

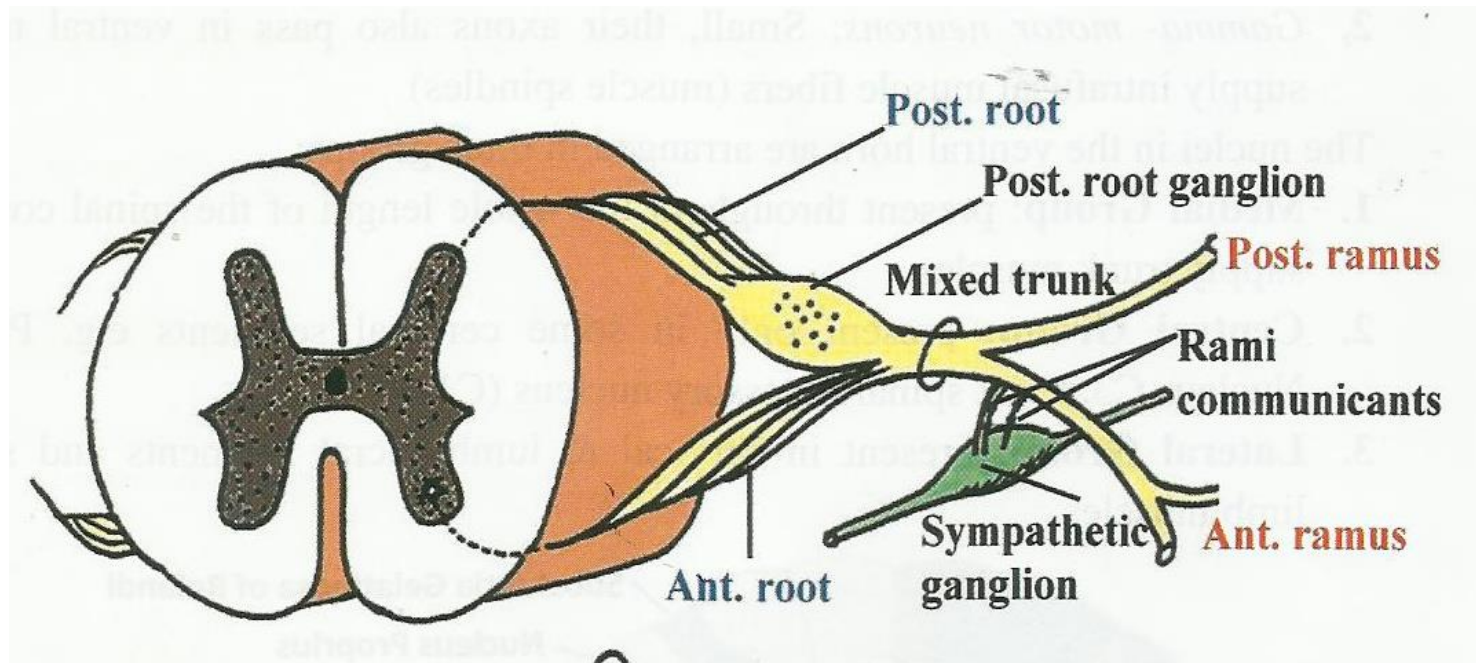
**2. Posterior ramus (small): supplies muscles & skin of the back.**





**FIGURE 12.27 (Continued) Anatomy of the spinal cord. (b)** Three-dimensional view of the adult spinal cord and its meningeal coverings.

- \*\* N.B: \* Both rami of C1 spinal nerve are purely motor.**
- \* Recurrent meningeal nerve:** It is the first branch of the mixed spinal nerve, just outside IVF. It re-enters the spinal canal via IVF to supply the dura, periosteum, blood vessels & I.V. discs. It plays a role in referred pain or occipital headache.



# Nuclei of Grey matter of Spinal Cord

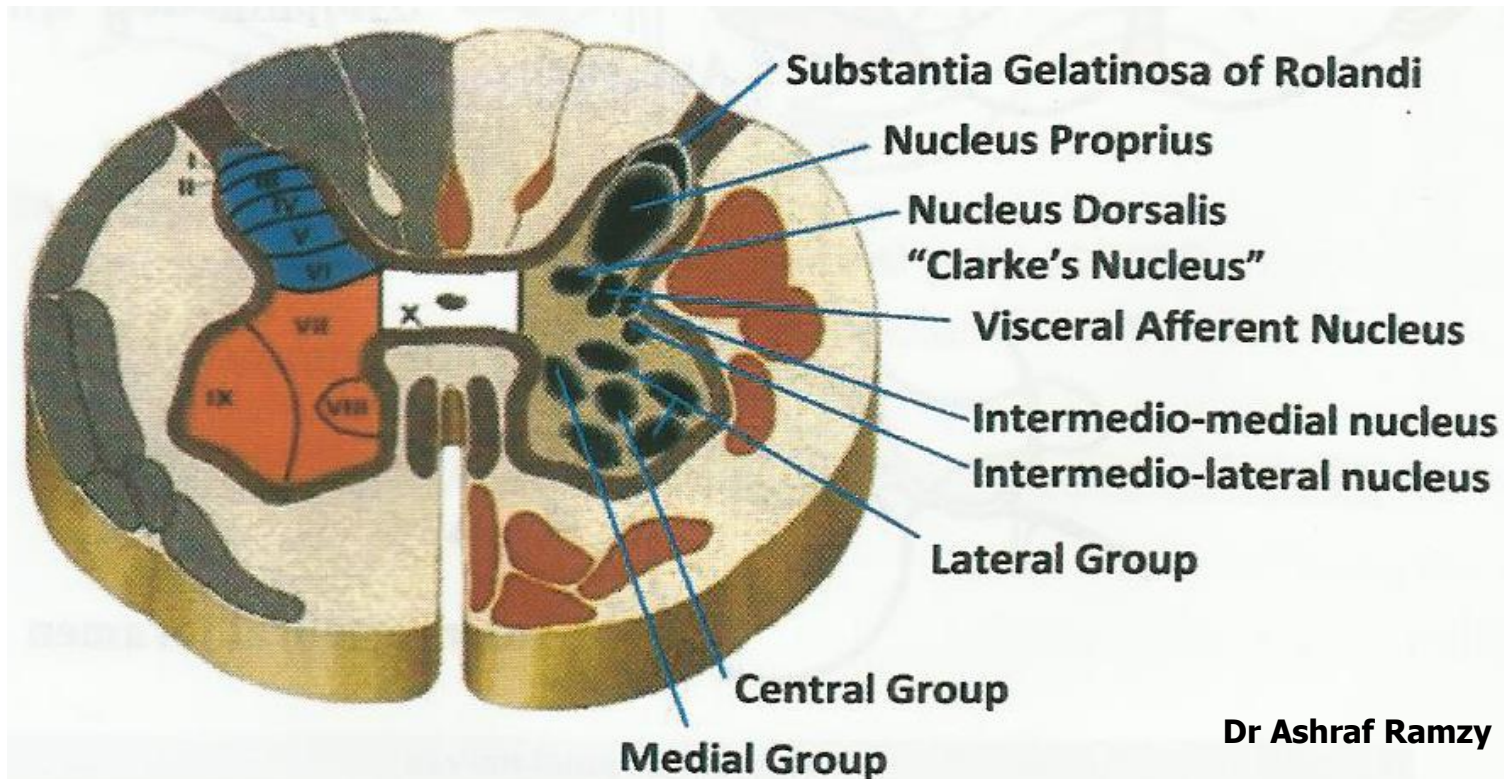
**A. In Dorsal Horn:** \* Nuclei are mainly sensory:

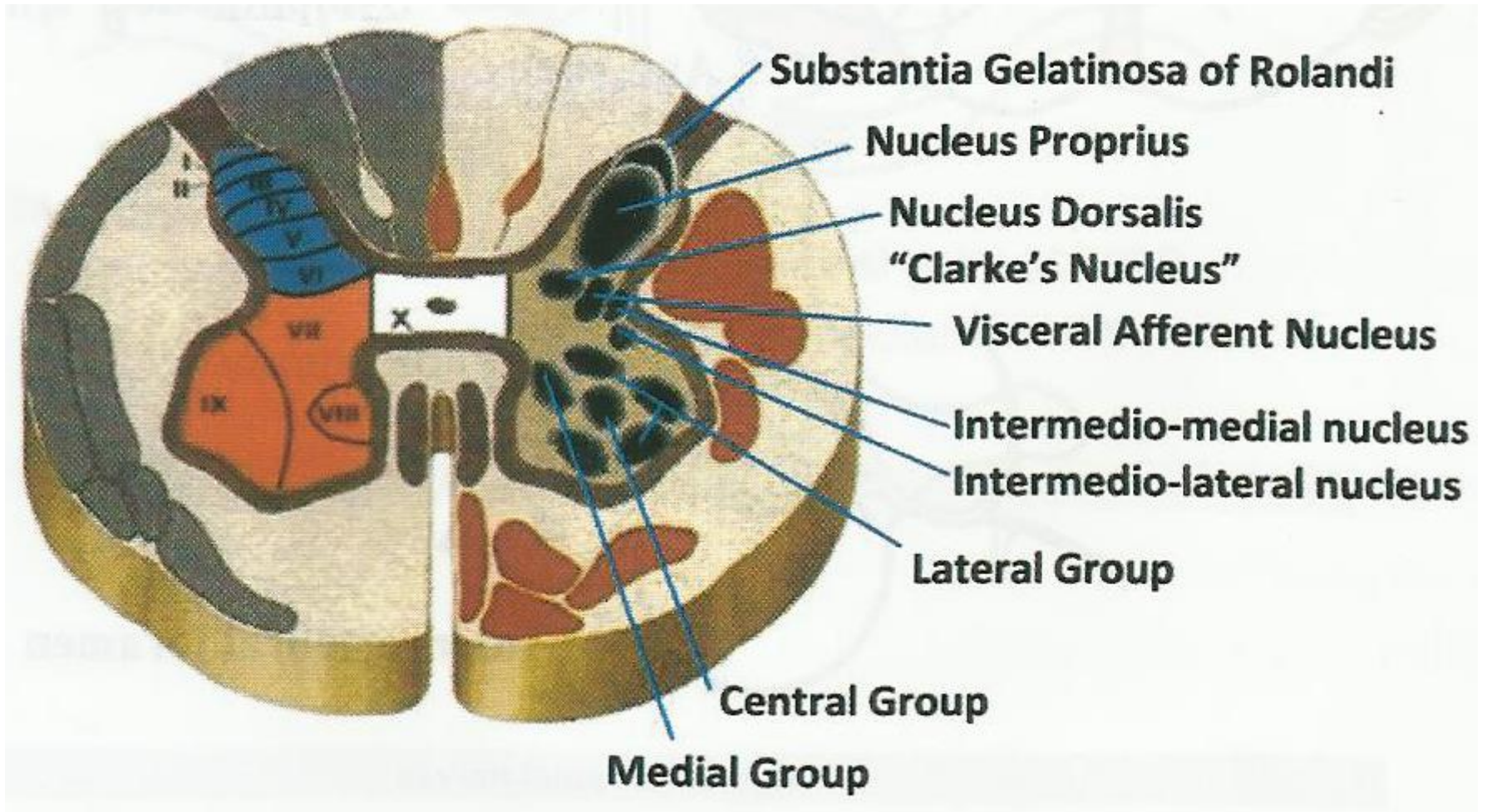
**1. Substantia Gelatinosa of Rolandi:** Present at tip of dorsal horn in all segments of spinal cord.

\* Function: pain modulation.

**2. Nucleus Proprius (Main sensory nucleus):** Present anterior to Substantia Gelatinosa in all segments of spinal cord.

\* Function: relays exteroception.



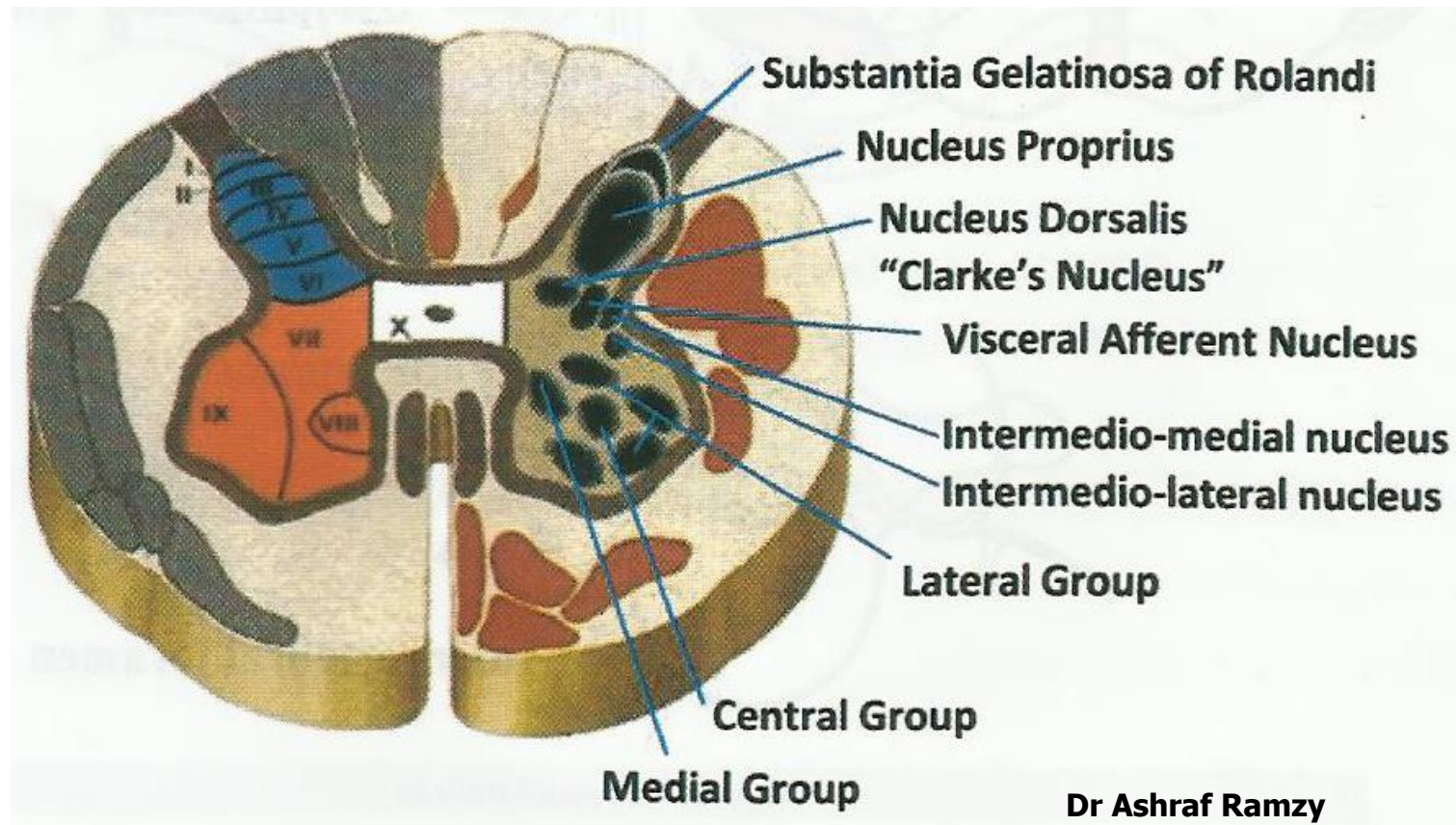


**3. Nucleus Dorsalis “Clarke’s Nucleus”:** Present at the base of dorsal horn in C8 to L3 segments of the spinal cord.

\* Function: relays unconscious proprioception.

**4. Visceral Afferent Nucleus:** Present in C8 to L3 segments of the spinal cord lies lateral to Clarke’s Nucleus.

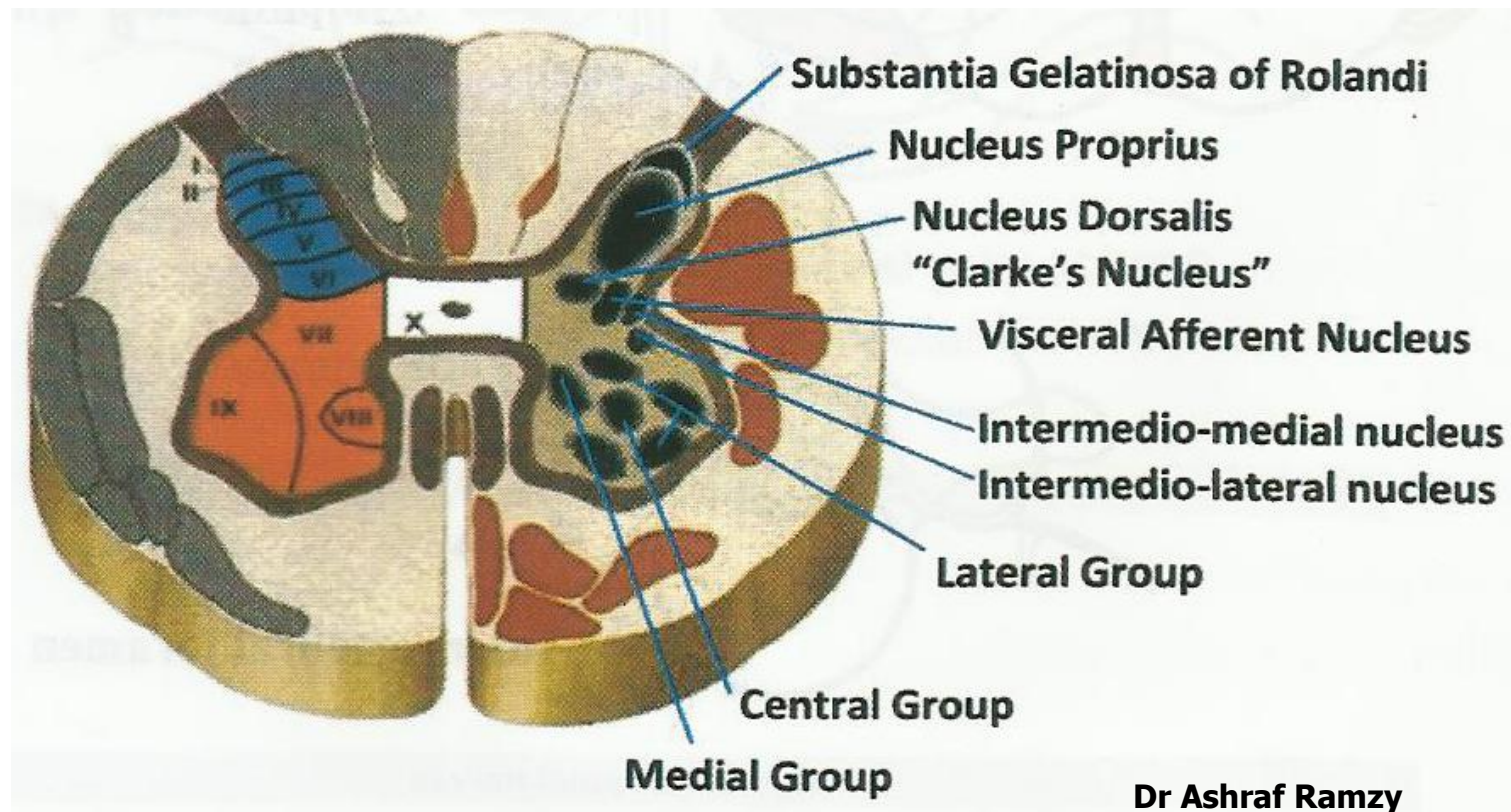
\* Function: relays visceral sensations.





## **B. In Lateral Horn:**

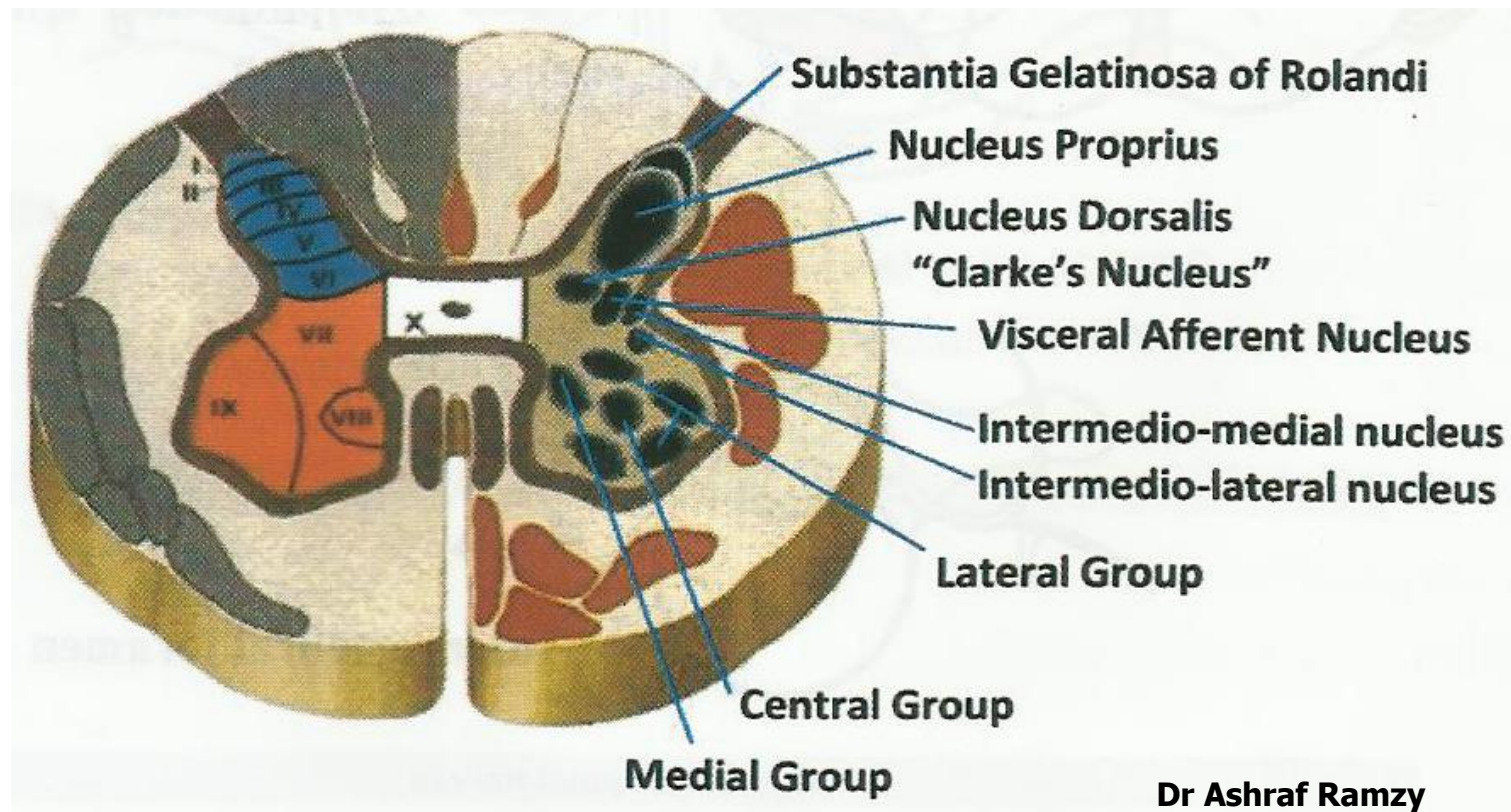
- \* Contains the intermediate nucleus present in thoracic & upper 3 lumbar segments. It is further divided into Intermedio-medial & intermedio-lateral nuclei. These are sympathetic neurons whose axons pass in the ventral root of the corresponding spinal nerves to reach the ganglia of the sympathetic trunk.
- \* A similar group of autonomic neurons “Sacral Parasympathetic” is present in S2,3,4 segments of the spinal cord but these do not form a lateral horn.



## **C. In Ventral Horn:**

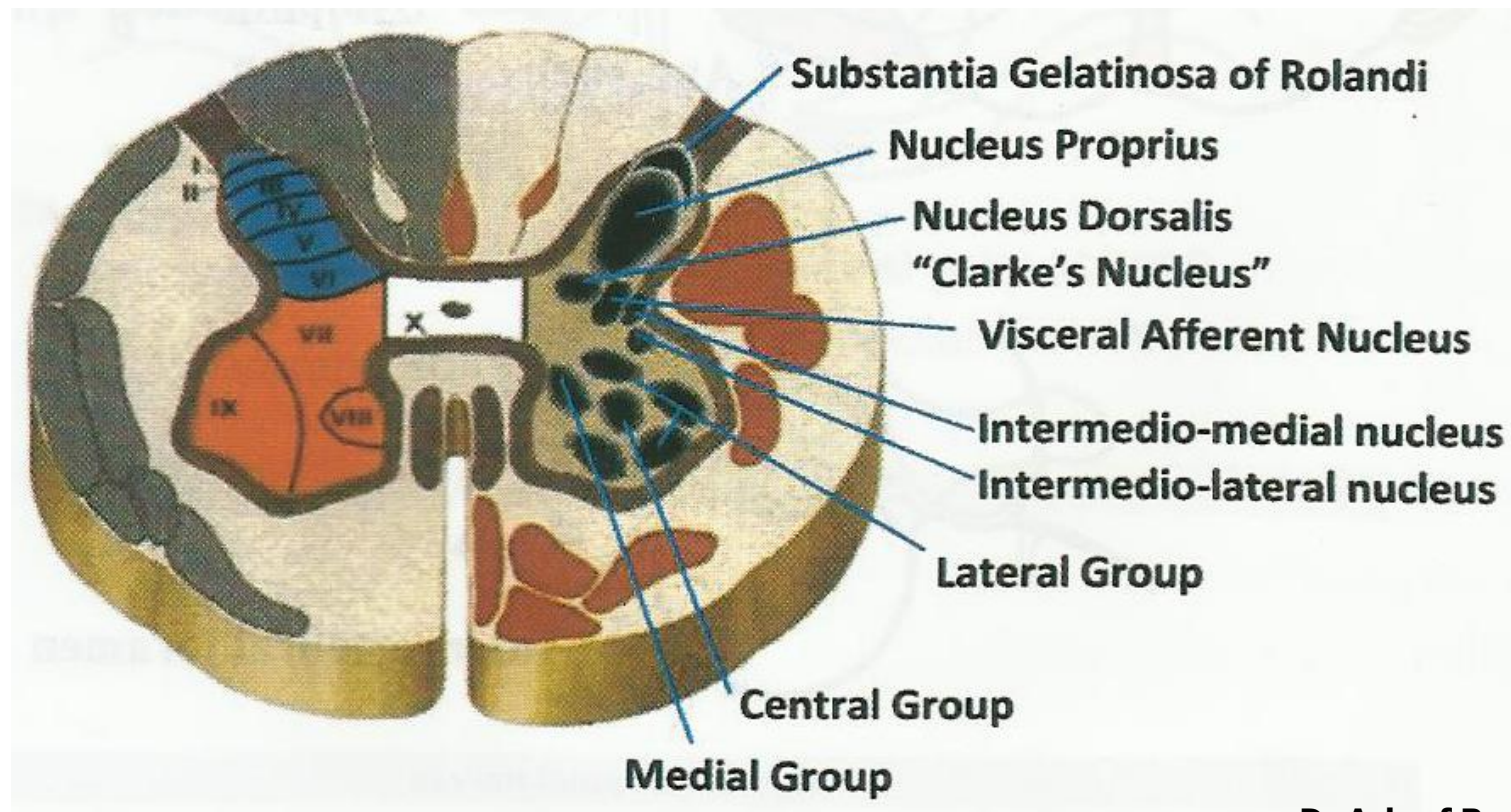
\* Nuclei are mainly motor neurons which are either:

- 1. Alpha-motor neurons (anterior horn cells- AHC):** Large, their axons pass in ventral root to supply extrafusal muscle fibers.
- 2. Gamma- motor neurons:** Small, their axons also pass in ventral root to supply intrafusal muscle fibers (muscle spindles).



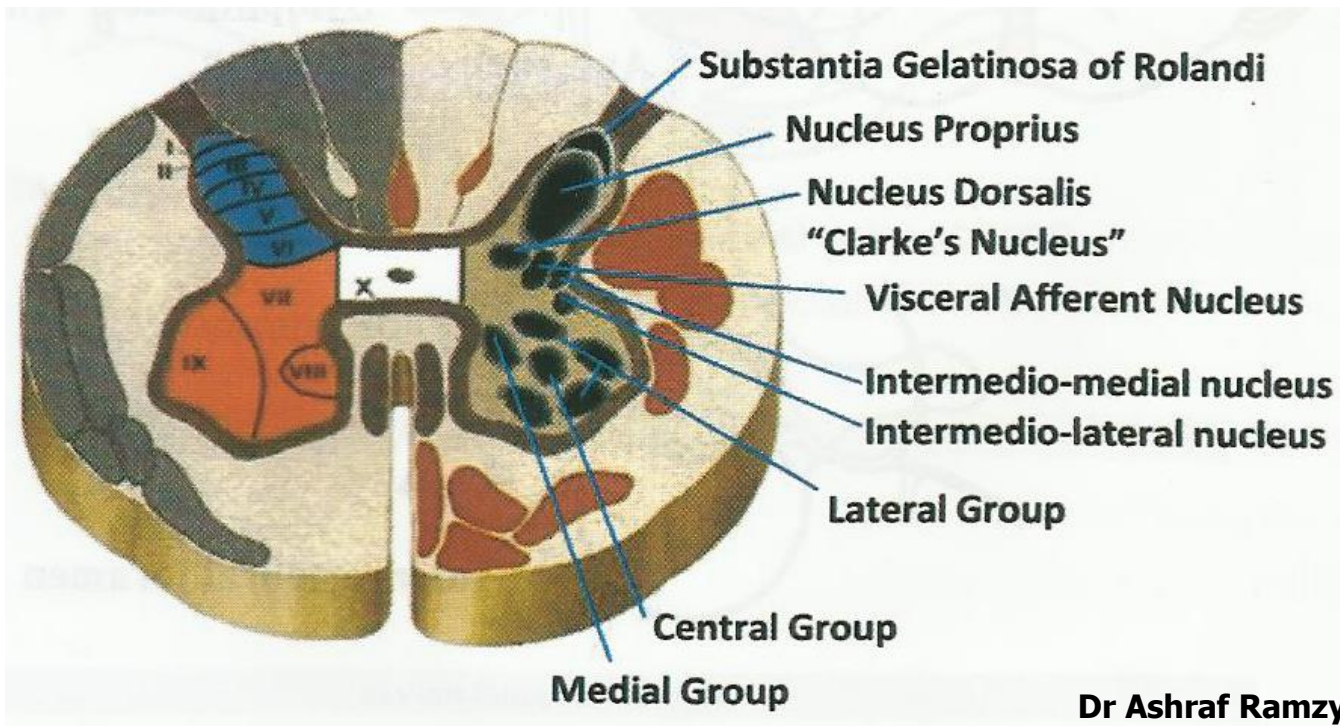
**\* The nuclei in the ventral horn are arranged in three groups:**

- 1. Medial Group:** present throughout the whole length of the spinal cord and supply trunk muscles.
- 2. Central Group:** present only in some cervical segments e.g. Phrenic Nucleus C3,4,5 & spinal accessory nucleus (C1-5).
- 3. Lateral Group:** present in cervical & lumbosacral segments and supply limb muscles.

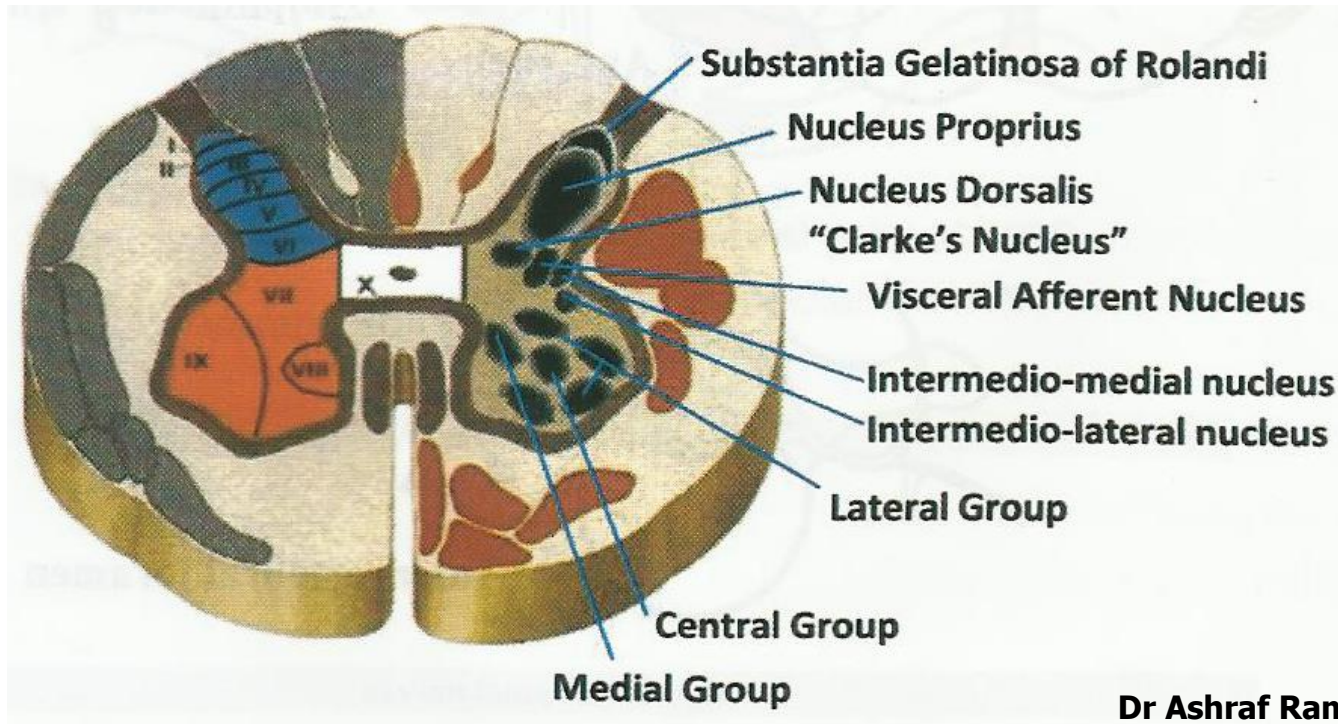


# Grey matter Laminae “of Rexed”

- \*\* **Rexed (1964)**: described 10 laminae in the grey matter of the spinal cord depending on: neurons size, density, shape & cytological features.
- \*\* **Laminae I -VI**: are sensory & occupy posterior horn.
- \* **L I** → marginal layer of Waldeyer.
- \* **L II + part of LIII** → Substantia gelatinosa of Rolandi.
- \* **The rest of LIII + L IV** → Main sensory nucleus.



- \* **Lamina VII** → occupies the lateral horn & extends into the middle part of the anterior horn.
- \* It contains: 1. Clarke's nucleus. 2. Lateral horn nuclei (intermediolateral & internediomedial). 3. Middle part of anterior horn (between L VIII & IX), contains Renshaw cells.
- \* **Laminae VIII- IX** → occupy the anterior horn. L IX is lateral. It contains the motor neurons. LVIII is medial. It controls the muscle tone.
- \* **Lamina X** → surrounds the central canal.



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